

**Maria Gloria Font Baste,
Amaya Caballero Marcos and Juan Briz Caro**

Universitat Politècnica de Catalunya, University of Barcelona,
Barcelona, Spain

**Environment on Architecture
and Construction Engineering Teaching
Our Experience in Url, Barcelona**

Philosophy of the course

Introducing environment concepts as a part of future engineers and architect's training is not just because it is a new business model for them or a new field for the profession; it is mainly a lesson with ethic compromises, with the intentions of increasing the understanding and respect towards the environment and the reality of our planet.

Construction is one of the industries with more connotations in the global contamination. The construction process puts together many fields and some of them are much more contaminating than others. Architects and construction engineers are involved in the design and construction process; neither of them can make big energy savings in terms of quantity but clearly in terms of concept. To encourage the awareness right from the beginning of those who will be involved in this field helps to increase their consciousness and the necessity to act towards and for the environment.

For us, the contribution in the education of architects and construction engineers¹ is about buildings that adapt to the environment in order to achieve maximum comfort from passive systems and not by thinking that they will need also energy systems to be completed.

At the same time, students will understand that each building is an integration of systems² that must coexist with each other. Energetic systems are born in mind with the spatial, the constructive and the structural systems.

In this way the students link all the subjects and what is being taught in relation to the environment and energy has a direct repercussion in their projection method from the first years of their learning.

Methodology

At early courses is where theories and practices of passive design are introduced in the way to give to the young students the basic tools to understand how energy works from the beginning.

In order to do that the building is analysed as an ecosystem that is exposed to external energies, and releases elements into the environment. From this point of view, we can study the incoming energies, the consequences of it and also the produced energies. Those analyses are done in different ways at our School: with specific trainings of particular subjects (such as simulation tools...) and with a general course where environmental and energy design concepts are taught and applied to examples.

That general course is done in two main knowledge themes: natural and artificial energies implicated to achieve the comfort. That comfort could be hydro-thermal, acoustic etc.

The first theme, "natural energies" is based on introduce conceptions of forms, materials and spatial arrangements to have a correct control of buildings.

That is explained from passive energy systems for hydrothermal comfort and a correct design for acoustic comfort.

The second theme, “artificial energies” is about the systems that have direct energy consumption and that give more comfort to the building. There are basically HVAC, lighting design and building services.

The main relation with environment and sustainability is in the first theme.

It is supported by weekly lectures, seminars and workshops.

Lectures

The environment analysis requires the knowledge of some physical concepts that are a little bit complicated for a twenty-year old student.

Hydrothermal comfort

In order to understand the energetic behaviour and to be able to apply in the right way the passive design solutions these concepts are grouped into the following topics about hydrothermal behaviour:

1. Comfort settings
 - Climates
 - Environmental control and comfort
2. Energy flows. Heat transfer fundamentals:
 - Conduction
 - Convection
 - Radiation
 - Isolation values
 - Thermal inertia
 - “Greenhouse” effect
3. Heating load application, gains and energy interchanges
 - Occupation
 - Artificial lighting
 - Other gains from used machines
 - External movement of air.

The course also looks at the relationship between climate and architectural evolution. Traditional and contemporary approaches are used as built examples. Maybe the best example of the adaptation into the environment in order to have comfort is the traditional architecture but is very important to show how it is used nowadays. The theoretical concepts can be seen in a range of techniques that the man created in different ways in order to adapt and take advantage of the environment.

To understand these techniques where the man applies the physical concepts explained, the students see it in two ranges of application:

1. Structural or passive methods (systems that doesn't consume energy they are produced by the design and construction)

- Environment: obstructions, settlement or adjoins
- Orientation: implication for each climate and use
- Shape: compactness, porosity and slenderness
- External surfaces: percentage of opaque and transparent surfaces
- Natural air movement. Passive systems that can move the air as solar shafts or wind towers
- Direct or indirect solar systems. Designs to obtain energy gains from the sun as solar walls, Trombe walls, sunroom...
- Direct or indirect systems to control solar gains as solar protections, patios...

2. Artificial or energetic methods (that have an energy consumption)

Those the concepts are of the second theme of the course, so there is a very important link between the two main themes. This link is done teaching some concepts like:

- Air renovation
- HVAC (heating, cooling, air conditioning)
- Artificial lighting.

Acoustic comfort

The acoustic comfort is a new big deal for the profession. It is a very complex theme and we only introduce it in the way that they can be able to understand the concepts that are usually applied and some important design premises like:

- Comfort concepts
- Physical-physiological concepts
- Equipping premises
- Absorbent materials
- Criteria of designing rooms
- Air traffic and impact noise insulation
- Analysis of different frequencies.

Seminars

Some of the concepts that are introduced theoretically are developed in short exercises that students do in class time individually. The more relevant ones are:

- Heat loss calculation_ They learn to calculate it manually in order to know which are the concepts that can change as designers in order to control the gains. At the same time they understand the design consequences and can evaluate which is the positive or negative loss in each climate conditions.
- Calculation and radiators distribution_ They practice designing a bitubular heating system for a simple dwelling as an example of energetic systems in relation with passive methods and energy loads.

Workshop

This is a hands-on workshop that provides training on the application of those concepts in a personal project. All the students are divided in group of twenty-five or thirty persons with a teacher for each group that check weekly their work progress. They work mainly in class (three hours per week) and some at home. The exercise is done in small teams of two or three students that can be future architects or engineers, learning from this early years how to work together like in real practice.

There are four exercises: two of natural energy and two of artificial. The natural ones are about energy and acoustics and the artificial are about lighting design and services.

All the objectives of the course are evaluated in three different ways: exams, individual work and group exercises.

Main course exercises

In order to analyse the relation with the environment the workshop about natural energy is done with the two exercises that involve design coordination: the one about passive design and the other about acoustic design.

The passive design exercise is based on a very simple program of a seventy square meter house with a workshop for a young architect. All students have the same program, but to pluralize the proposals two sites in an urban context and with similar dimensions but different orientation are given as project site.

In order to assign a climate to work in it, we are working around our city. Barcelona is in a region that globally is temperate, the Mediterranean, but in our next territorial context we have some different climates because of the topography, sea distance, high mountains existing...that allows us to speak about three basic climates: cold, warm-dry and warm-humid. This classification gives to the students nearly examples like the typical Pyrenees or arabian dwelling. But also, in a world-wide vision, they can extrapolate it to a global level as an igloo or a typical tropical house.

Students design the small house replying with passive systems to the typical characteristics of each climate. The project must include:

A context analysis noticing the meteorological and physical environment characteristics. Best orientation, existing shadows, usual winds...

A fixed list of the main aims to achieve and the main problems to be considered.

A complete design of spatial issues and best relation between spaces and functionality.

Definition of the construction type and details, showing all the façade components and explaining why it is chosen as the best solution for each project.

Evaluation of the project in relation with the environment, how it works in each time of the day and the night and in each season of the year (Figure1).

Heating loss calculation of one façade or roof which is basic for the project, depending on it.

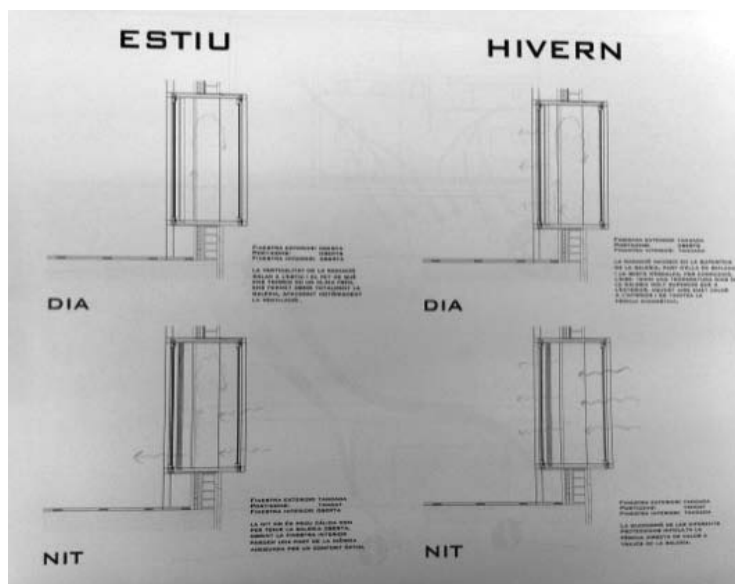


Figure 1. Illustration of students group work, energy output

According to us, that is the clearest way to see the range of possibilities to be energy efficient taking into account the other systems that is part of the project.

The acoustic design is raised with an exercise that consists of correct design acoustic conditions for a conference hall.

The students have an existing hall that is located in the university in order to be able to visit it. They must adapt to the new use changing interior geometry, space and materials. They also need to calculate the reverberation time and obtain a correct one for the new use adapting geometry and materials to it.

The project must include:

A single studio of the existing hall conditions.

A complete design of the conference hall. Spatial conditions, materials and functionalities.

The construction description with materials remain on the acoustic characteristics of each one.

Reverberation time calculation.

There other two exercises are about artificial energies so they are not really involved in environment issues. The lighting is studied by the design of an exposition hall where they must define which lamps are been considerate and why they have been chosen. They also do a manual calculation of the illumination. The services are introduced with the identification of the services that each one has in their own house.

Conclusions

In each way of the evaluation the student shows what they have learnt:

- Exams. They show that they have learned how to design and use the systems, components, processes or experiments to reach the established requirements and to analyse and interpret the results obtained. It also shows their ability to calculate in a manual way.
- Individual work. They have understood the environmental impact of building industry and the importance of working in a professional environment and being ethically correct.
- Group work. The student learns to have the technical and planning knowledge for the practice of the profession. They also identify, formulate and solve related problems in a multi-disciplinary environment, as members of a team that is composed of future architects and construction engineers working together as in real practice. They are improving their capacity to criticize, also to be self-critical and to appreciate the diversity of the many disciplines which form part of the process.

They also achieve different personal skills as capacity for analysis and synthesis and ability to plan and organize the necessary knowledge to develop the area of study and to put into practice.

The main goal to introduce such a relevant and difficult problem as is the relationship with the environment as the first objective of a project is that it means a great effort for the students. That is why after this exercise they usually integrate all the passive design concepts into their natural way to project.

We are satisfied with the general results but sometimes the student have too many inputs and complexity for their age and is in the following years when they really understand and applied it into their own designs.

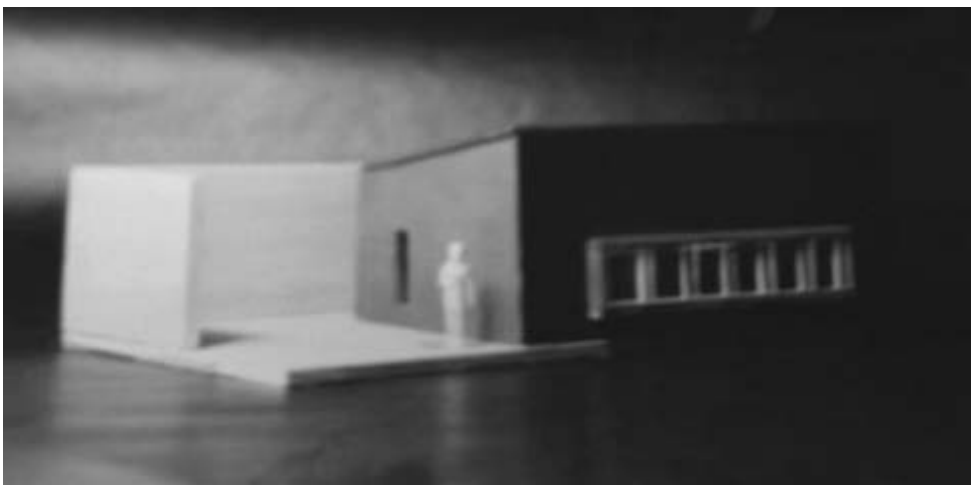


Figure 2. Picture of the model of a students group

Acknowledgements

This paper is a short resume of the work that has been carried out in the university since its foundation ten years ago. Many people, teachers and also alumni, collaborate directly or indirectly to develop it and consolidate the course and the importance of teaching environment in our school.

Illustrations and references

Pictures from the work of E.Sala and S.Osuna students on 2001-02 course

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Endnotes

1. In our School both undergraduates share most of the courses.
2. In a building process we can identify four systems: spatial, structural, construction and energetic (that includes natural and artificial energy, it means energy performance and building services).